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MATHEMATICS FOR NON-MATHEMATICIANS.

By WILLIAM PAGET HIGGS, LL.D.

Division I.—The Algebra of Constant Quantities.

(Continued from p. 170.)

Positive and Negative Quantities.

Hitherto we have been dealing with *positive* quantities,—that is, with those quantities which are arrived at by counting upwards from zero or 0. But let us imagine ourselves counting *downwards* from zero or 0, and we arrive at so many "less than nothing." "Less than nothing," however, as I shall presently endeavour to show, is an incorrect expression. It is convenient to call those quantities above 0 *positive*, and those below 0 *negative*. Positive quantities may or may not have the positive sign (+) prefixed to them, but negative quantities have always the negative or minus sign (−) prefixed. $+a$ is a positive quantity; $-a$ is a negative quantity.

In order to perfectly understand the distinction between positive and negative quantities, we may consider two illustrations.

I have a thermometer, and I plunge it into warm water. The instrument indicates say 20° of heat, and this may be written +20°. Or I plunge the thermometer into a freezing mixture, and the mercury sinks below zero, say 20°; this may be written −20°. 20° of heat is then written +20°, and 20° of cold is written −20°. Now 20° of cold is not 20° "less than nothing;" indeed it is a *positive want* of 20° of heat to bring about the normal or zero condition.

The second example will be still more familiar. I *have* three apples, and I may write this as $+3$ or $+3a$; I *want* three apples, and I may write this as -3 or $-3a$. In the latter case it will take three apples to satisfy my want, and another three apples to make me rich in the amount of three apples.

Thus, $-3a$ does not mean three apples "less than nothing," which would be an absurdity, but it means a *want* of three apples to restore my appetite for fruit to its normal state, or state of no desire.

The expression or equation, it will be seen, holds good that—

$$-3a+6a=+3a,$$

for if we take $6a$ as being composed of two $3a$'s, it will absorb one $3a$ to satisfy the want expressed by the negative or minus sign, and we shall have one $3a$ remaining.

If the reader have mastered the distinction between positive and negative quantities, he has passed the *pons asinorum* of algebra. If he be in possession of the correct meaning, he will understand that the distinction consists in measuring in two different directions,—that is, if by + he is told to measure to the right, by − he knows he is to measure to the left. The signs indicate opposition,—to add to, and to take from,—the possession, and the want of.

That the reader may be assured of his comprehension let him resolve for himself the following equations:—

$$-20+10=-10,$$
$$10-20=-10.$$

$$-2p+6p-4p=0,$$
$$-4p+6p-2p=0,$$
$$6p-2p-4p=0.$$

The last expression leads to the consideration of the mathematical use of *brackets*. Brackets in mathematics are similar in form to the brackets...( )...[ ]...of print or of writing, but they do not, as those in print, indicate inferiority or illustration. Mathematically they are signs indicating *collection*. Thus in the expression—

$$6p-2p-4p=0,$$

the repetition of subtraction indicated by $-2p-4p$ would be equally well represented by $-(2p+4p)$, or by adding the two negative quantities and taking their sum from $6p$, with the result $=0$. Brackets are employed to class or collect together several *simple* quantities which may be taken together as one *compound* quantity. Instead of brackets, the *vinculum*, a line drawn above the compound quantity is sometimes used. Thus the following are identical expressions:—

Brackets.	Vinculum.
$6p-(2p+4p)=0.$	$6p-\overline{2p+4p}=0.$

Brackets sometimes occur within brackets, and then the following arrangement is most general:—

$$12p-[6p+(2p+4p)]=0.$$

Though simple the reasoning we have followed, the rule for subtraction may be stated even more simply. *Change the signs of all the quantities to be subtracted, and then add,*

Let us test this numerically—

By subtracting a positive number from a positive number, as $4-2=2$, and $4+(-2)=2$, or rendering a positive number less positive, for in the latter case it takes 2 of the positive number 4 to satisfy the want expressed by the negative sign prefixed to the 2.

By subtracting a negative number from a positive number, as $4-(-2)=6$, which is simply a direction to perform the operation of subtracting or removing the *want* of 2—expressed by (-2)—from the 4. We may consider this as a direction to increase a positive number, the direction being written under a negative form.

By subtracting a negative number from another negative number, as $-4-(-2)=-2$, or, in other words, removing the want expressed by the negative quantity (-2).

By subtracting a positive number from a negative number, as $-4-2=-6$, or rendering a negative quantity still more negative.

Let us regard the question, which is one of great difficulty, in another light. We know that 4 may be written $4+2-2$; for as $2-2$ equal nothing, the addition of 0 to 4 does not alter its value. Let us consider subtraction as meaning "taking away," and, starting with $4+2-2=4$, let us see the effect of "taking away" first the $+2$ and then the -2, which is simply a repetition of the examples given above in subtracting a positive or a negative number from a positive number. Thus—

Subtraction from a positive number.

4	+2	−2	=4
4	*	−2	=2
4	+2	†	=6

Similarly we may illustrate the two examples remaining, by considering −4 as written −4+2−2, where, as before, 2−2 is nothing.

Subtraction from a negative number.

−4	+2	−2	=−4
−4	+2	†	=−2
−4	*	−2	=−6

* Taking away the positive number.
† Taking away the negative number.

Thus we can perceive the reason for the following *rules for brackets*:—

If the sign + be before the brackets, the brackets may be removed without altering the value of the expression.

If the sign − be before the brackets, remove this sign with the brackets, and change all the signs of the quantities within the brackets.

ON SOME

IMPROVEMENTS IN ELECTRO-MAGNETIC INDUCTION MACHINES.*

By H. WILDE.

Soon after my announcement (in 1866) of the discovery that electric currents and magnets indefinitely weak could, by induction and transmutation, produce magnets and currents of indefinite strength,† a number of electricians suggested other methods by which this principle could be exhibited and more powerful results obtained than those which I had described.

The most interesting as well as the most useful of these suggestions was to augment the magnetic force of the elementary magnet, by transmitting the direct current from the armature of a magneto-electric or an electro-magnetic machine, through wires surrounding its own permanent or electro-magnet, in such a direction as to intensify its magnetism, until, by a series of actions and reactions of the armature and the magnet on each other, an exalted degree of magnetism in the iron or steel was obtained.

This idea seems to have occurred to several electro-mechanicians almost simultaneously in England, Germany, and America.

At the time when this method of exciting an electro-magnet was brought prominently forward, I directed attention to the fact that machines as constructed are incapable by themselves of producing powerful electric currents, as the whole energy of the machine is expended in exciting its own electro-magnet.‡ Besides this, the actual amount of electricity circulating round the electro-magnet is really very small; and when the circuit is opened for the purpose of applying the current to some useful purpose, the magnet immediately discharges itself, and resumes its neutral condition till the continuity of the metallic circuit is re-established.

While the current transmitted from the armature of a magneto-electric or an electro-magnetic machine, as I have said, is incapable of directly producing powerful electro-dynamic effects, such current may be usefully employed to excite the electro-magnets of other machines in accordance with my original method. Some idea of the smallness of the quantity of electricity requisite for this purpose will be formed from the fact that the full power of a 10-inch machine is developed when its electro-magnet is excited by the current from four pint Grove's cells.

This machine has been in constant operation for some time past for the electro-deposition of metals from their solutions, and its electro-magnet is now excited by its own residual magnetism in the following manner:—A small magnet-cylinder (3·5 inches diameter and 14 inches long) is bolted to the top of the 10-inch cylinder, so that the sides and axis of the former are parallel with the similar parts of the latter. The cylinders are separated for a space of three-quarters of an inch by a packing of brass, and consequently act upon each other by induction through the intervening space, instead of by contact as in ordinary methods of magnetisation.

The residual or permanent magnetism of the large electro-magnet with its cylinder is very considerable, being many times greater than that of the four small permanent magnets with which it was originally excited.* The coils of the small armature are placed in connection with those of the great electro-magnet; and when the armature is rotated the magnet-cylinders act and react on each other, until the electro-magnet is excited to the highest degree of intensity. By this arrangement of the armatures and cylinders the minor current for exciting the electro-magnet is kept distinct from the major current from the larger armature, which may be coiled for currents of high or low tension, according to the purpose for which they are required.

It is essential, for the attainment of a high degree of magnetism in an electro-magnet excited by magneto-electricity, that the continuity of the armature and electro-magnetic circuits should be preserved during the change of contacts from one segmental part of the commutator to the other. For this purpose the segments are made to overlap each other for a short distance, so that the metallic rubbers or brushes for taking off the current bear on adjoining segments simultaneously at the point of no current, and, in so doing, form two closed metallic circuits for a brief interval, which may be represented by the numeral 8, the upper part of the figure representing the armature circuit, and the lower part that on the electro-magnet; but when the armature is at that part of its revolution when the currrent begins to rise in intensity, the coils of the armature and electro-magnet form one continuous circuit, which may be represented by the cipher 0. The importance of keeping the circuits closed in the manner described was not sufficiently observed in my earlier experiments, and necessitated the employment of much more powerful currents for exciting the electro-magnets than were afterwards found to be necessary.

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* Abstract of a paper read at a Meeting of the Literary and Philosophical Society of Manchester, April 15, 1873. Communicated by the Author.

† "Proceedings of the Royal Society," April 26, 1866. "Phil. Trans.," vol. clvii. (1867). "Phil. Mag.," S. 4, vol. xxxiv., p. 81.

‡ "Proceedings of the Literary and Philosophical Society of Manchester," vol. vi., p. 103.

* The small scale upon which my experiments have been repeated by physicists has, in some instances, given rise to the idea that the residual magnetism of an electro-magnet is a lower degree of permanent magnetism than that which originally formed the basis of my augmentations.

So far as I have communicated the results of my investigations on the principle of accumulative action in electro-dynamics, they have been obtained with machines designed with reference to the peculiar form of armature contrived by Dr. Werner Siemens, of Berlin. While possessing several advantages in point of efficiency over that of Saxton, the Siemens armature requires to be driven at a high velocity to produce a succession of currents sufficiently rapid to be available as a substitute for the voltaic battery. Little inconvenience, however, arises from the high speed when the armatures are of small dimensions; but as the dimensions increase it becomes necessary to lower the speed, and the large machines are consequently not proportionately powerful in comparison with the smaller ones. Besides this, the advantage possessed by this form of armature, in having the moving mass of metal near the axis of rotation, is neutralised as the dimensions increase, by the excessive heat generated by the magnetisation and demagnetisation of the iron. It would also be convenient in some circumstances to drive a machine direct from the crank or fly-wheel of a steam-engine without the intervention of multiplying gearing.

Considerations of this nature led me, towards the end of 1866, to propose to myself the construction of an electro-magnetic machine with multiple armatures, which should remove the inconveniences inherent in those hitherto constructed by producing a greater number of currents for one revolution of the armature axis. Since that time I have been engaged, with more or less interruption, in carrying out this design, and have at length constructed a machine the performance of which surpasses all my previous essays in this direction in regard to power and efficiency, and with a considerable reduction in the quantity of the materials employed.*

The machine in which these results are embodied is represented in Fig. 1. A A are the two sides of a circular framing of cast-iron, firmly fixed together by the stay rods, B, and the bridge, C. A heavy disc, D, of cast-iron is mounted on a driving-shaft, E, running in bearings fitted to each side of the framing. One of these bearings, F, is carefully insulated from the framing by suitably-formed pieces of ebonite, and also from the shaft by a cylinder of the same substance. Through the side of the disc, and parallel with its axis, sixteen holes are bored, at equal angular distances from each other, for the reception of the same number of cores or armatures, G. The cores project about 2 inches through each side of the disc, and are held firmly in their places by screws tapped through its periphery. Around each inside face of the circular framing, and concentric with the driving-shaft, sixteen cylindrical electro-magnets are fixed at the same angular distance from each other and from the centre of the shaft as the iron cores round the disc; the two circles of magnets consequently have their poles opposite each other, with the disc and its circle of iron cores revolving between them. The ends of the cores are terminated with iron plates, of a circular form, which answer the double purpose of retaining the helices surrounding the cores in their places, and overlapping for a short distance the spaces between the poles of the electro-magnets. The closing of the *magnetic* circuits of the electro-magnets and armatures for a short distance, like the closing of the *electric* circuits for a brief interval at the point of no current, has a marked influence on the power of an electro-magnetic induction machine,—both contrivances conspiring, simultaneously, to maintain the magnetic intensity of the electro-magnets during the rise and fall of the magneto-electric waves transmitted through the helices.

The cylindrical bar magnets are each coiled with 659 feet of copper wire, 0·075 of an inch in diameter, insulated with cotton; the helices are grouped together to form a fourfold circuit, 2636 feet in length, and are joined up in such a manner that adjacent magnets in each circle, as well as those directly opposite in both circles, have north and south polarity in relation to each other. A charge of permanent magnetism was imparted to the system of electro-magnets by the current from a separate electro-magnetic machine.

The armatures, although formed of sixteen pieces of iron, are, by projecting through both sides of the disc, thirty-two in number. The length of insulated wire on each armature is 116 feet, and the thickness is the same as that on the electro-magnets. These helices are divided into eight groups of four each, and coupled up for an intensity of 4×464 feet. One of the groups is used for producing the minor current for exciting the circle of electro-magnets, while the remaining groups are joined together for a quantity of seven, and an intensity of four for the production of the major current from the machine. The aggregate weight of wire on the electro-magnets is 356 lbs., and on the armatures 26 lbs. The helices for exciting the electro-magnets are connected with the commutator, H, while those producing the major current are placed in connection with the rings, I, K, or in place thereof with another commutator, according as the alternating or the direct current from the machine is required. The strength and proportions of the several parts of the machine enable it to be driven with advantage from 300 to 1000 revolutions per minute.

At the medium velocity of 500 revolutions per minute the major current will melt 8 feet of iron wire 0·065 of an inch in diameter (No. 16, B. W. G.), and will produce two electric lights in series, each consuming carbons ½ an inch square at the rate of 3 inches per hour.

When driven at a velocity of 1000 revolutions (equivalent to 16,000 waves per minute), the current will fuse 12 feet of iron wire 0·075 of an inch in diameter (No. 15, B. W. G.). As soon as the heating or fusing of an iron wire of a given length and section comes to be an acknowledged measure of powerful electric currents, as well as a method of comparison between the power of electromotors of different kinds, as it must ultimately be, the significance of this result will be fully realised.

At the velocity of 1000 revolutions per minute the light from two sets of carbons in series is unendurably intense, as well as painful to those exposed to its immediate influence. Estimated on the basis afforded by the performance of the excellent magneto-electric-light machines of MM. Auguste Berlioz and Van Malderen, who have made a careful study of the photometric intensity of the electric and oil lights, the power of the new machine is equal to that of 1200 Carcel lamps, each burning 40 grms. (1·408 ozs. avoird.) of oil per hour, or of 9600 wax candles. The amount of mechanical energy expended in producing this light is about 10 indicated horse-power.

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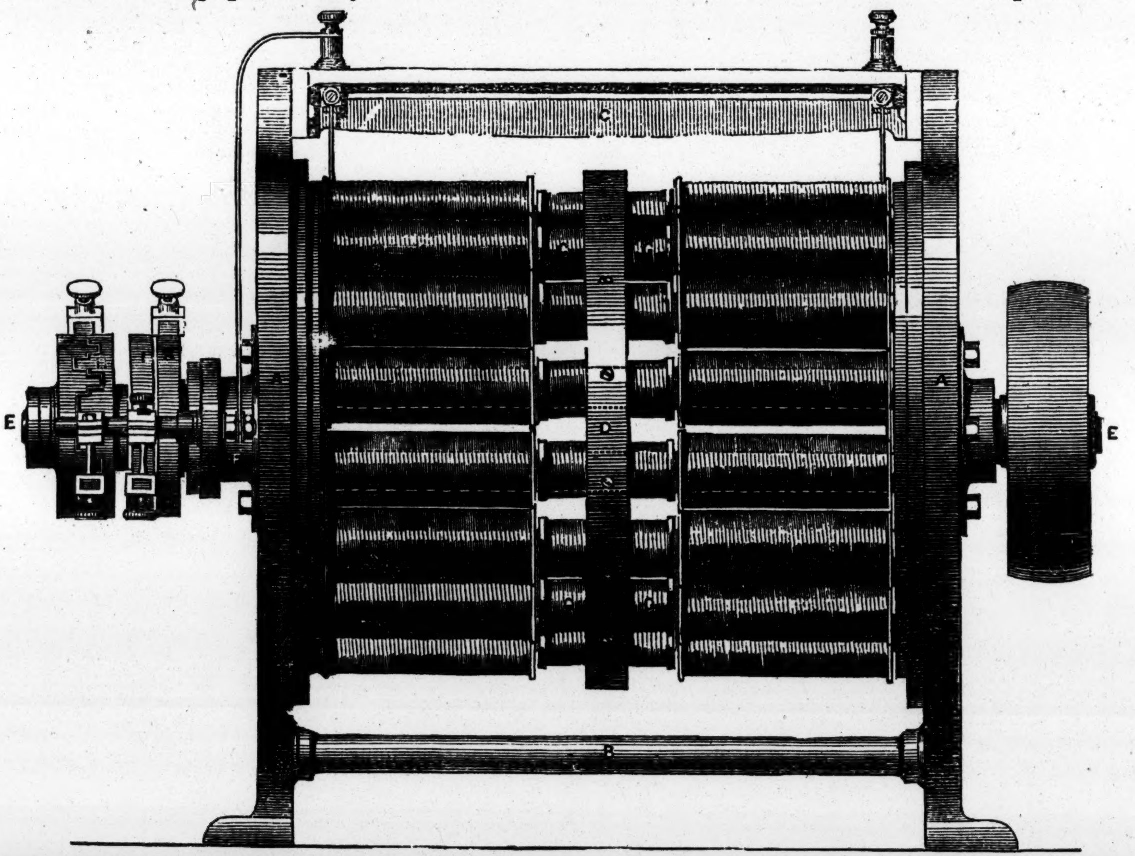
* A general description of the improvements which form the subject of this paper was deposited in due form with the Commissioners of Patents, London (December, 1866, and March, 1867), and with the Ministère de l'Agriculture et des Travaux Publics, Paris (June, 1867).

A comparison between the power of the new machine and that of the 10-inch machine will show that while the current from the former fuses 12 feet of iron wire 0·075 of an inch in diameter, the current from the latter fuses only 7 feet of wire 0·065 of an inch in diameter, and is consequently only about half as powerful as that from the new machine. Besides this, the quantity of copper used in the construction of the new machine is about 3½ cwts., and of iron 15 cwts., while the weight of these metals in the 10-inch machine is 29 and 60 cwts. respectively. In other words, we have in the new machine a double amount of power, with less than one-fourth the amount of materials employed in the construction of the 10-inch machine.



Another advantage possessed by the new machine is the great reduction of temperature in the armatures by their rapid motion through the air, which acts much more efficiently than the circulation of water through the magnet-cylinder. By increasing the diameter of the electro-magnetic circles conjointly with the number of electro-magnets and armatures, the angular velocity of the machine may be so diminished that it may be driven directly from the crank of a steam-engine, concurrently with an increase of electric power proportionate to the number of electro-magnets and armatures in the electro-magnetic circles.

While the excitation of the electro-magnets of the machine by the current, from several of its armatures, is attended with some advantages where portability is required, yet, as provision has to be made for keeping the major and minor currents separate from each other, the commutator arrangements become somewhat complicated, and faults in either of the circuits are not so readily localised as when a separate exciting machine is employed. In those cases, therefore, where conveniences for driving separate machines are at hand, and when the power of several of them is required simultaneously, as in large electro-depositing establishments, some advantage will be gained by using a separate machine of suitable power to excite the electro-magnets of several machines, when the currents from the whole of them may be utilised, and a commutator on the axis of each machine will be dispensed with.

In my paper "On a Property of the Magneto-Electric Current to Control and render Synchronous the Rotations of the Armatures of a Number of Electro-Magnetic Induction Machines,"[*] I stated that this property would be available when the machines were used for the electro-deposition of metals from their solutions. It has, however, been found that the small resistance presented by depositing solutions to the passage of the currents prevents this property from manifesting itself (in accordance with what I stated in my paper respecting the effect of joining the poles with a good conductor; and it is only when the machines are employed for the production of electric light, or other purpose where the external resistance is considerable, that this electro-mechanical function of the current comes into useful operation.

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[*] "Proceedings of the Literary and Philosophical Society of Manchester," December 15, 1868. "Phil. Mag.," S. 4, vol. xxxvii., p. 54.

THORNTON HUNT.

Peacefully there passed away from us, at midnight of Wednesday last, the spirit of a great thinker. Thornton Hunt, the eldest son of Leigh Hunt, was the companion, in his earlier years, of Shelley and Lamb. Later he studied art, and then sought the labours of a journalist. First connected with the *Constitutional*, then editing the *Chester Reformer* and the *Glasgow Argus*, returning to London, and undertaking the principal share of the work of the *Spectator*, the *Leader*, and the *Globe*, he subsequently for eleven years edited the *Daily Telegraph*. The last journal to which he devoted his wonderful energy says—"Mr. Hunt was long associated with this journal, and none ever more conscientiously fulfilled in the largest sense the written and unwritten letter of his engagements. Indefatigable, self-sacrificing, trustworthy in the highest sense, beloved by all his colleagues for his frank, manly, and amiable personal qualities, he made daily intercourse chivalry, while he gave his best efforts, without stint, to the service of the public. This tribute is due to his memory, which will always be cherished by his comrades and by those who knew him well." We, too, would bear witness to his exertions for the *Telegraphic Journal* in its infancy, the kindliness and value of his advice from time to time, while we would wish to add to the list of his labours the deep thought expended on the correlation of natural forces, especially with regard to the unknown force of electricity.

Students' Column.

Retardation in Overhead Wires. By Robert Sabine, C.E.

The rate at which signals can be transmitted through overhead wires is very much greater than upon submarine or underground lines, because the retardation is less.

Both aërial wires and cables are, however, subject to precisely the same laws, differing only in degree as regards retardation, and the same general formulæ, therefore, apply to both. Attempts have been made, at different times, to determine the transit velocity of the electric wave in line wires: and results have been arrived at which, although appearing to be very various and inconsistent as they are generally stated, are nevertheless, in most instances, reducible to concordant expressions. Where this is not the case, the difficulty lies in the absence of any information to guide us to a conclusion as to the conditions of induction and resistance under which the experiments were made.

In the Students' Column of No. 8 of this Journal, I drew attention to the fact that on the arrival at the far end of a line, by an electric wave, work has to be done before the wave can be recognised, and that the issuing wave requires time to gain strength enough to perform this work. There are different ways in which this work has to be performed according to the different ways in which the wave is recognised. In Sir C. Wheatstone's celebrated experiment, in 1835,* with a revolving mirror, he found through a copper wire, 0·2 inch diameter, suspended in the vaults of King's College, that a spark took $\frac{1}{1150000}$ second to pass from one end to the middle ($\frac{1}{4}$ mile in length), which represents a velocity of 288,000 miles per second. In this case mechanical effect was performed by the arriving wave in springing over $\frac{1}{10}$th inch of air in the form of a spark. The work it had to do was to collect on the other side, through $\frac{1}{4}$ mile of wire, a sufficient induced charge, and when it had done this to push back the intervening air and to jump across. If in this experiment, from the given data we may roughly estimate the resistance by the $\frac{1}{4}$ mile of wire to have been 0·4 ohms; and its electrostatic capacity at 0·0025 micro-farad, which is at the rate of about $\frac{1}{30}$ that of an average submarine cable, that which I have called the coefficient of retardation would be—

$$a = \frac{1}{1150000 \times 0{\cdot}4 \times 0{\cdot}0025} = 870{,}000 \times 10^{-9} \text{ seconds}$$

that is to say, that as a receiving instrument, a spark apparatus having a striking distance of 0·1 inch would be $\frac{870{,}000}{414}$, or about 2000 times less sensitive than a Morse electro-magnet; in other words, that the time required for the arriving wave to get strength enough to do its work would be 2000 times as long, and transmission by such a method 2000 times as slow, as by Morse.

In 1848 Walker used a Bain's instrument for determining the velocity of a current in the line from Boston to New York, a wire length of 220 miles, and found that the signal occupied a mean of 0·0029 seconds. Assuming the line resistance to have been (17 ohms per mile) 3740 ohms, and the capacity (0·01 micro-farad per mile) 2·2 micro-farads, the coefficient of retardation would have been—

$$a = \frac{0{\cdot}0024}{3740 \times 2{\cdot}2} = 291 \times 10^{-9} \text{ seconds.}$$

But Walker's results do not appear to have been very regular; and considering the crudeness of the method of measuring this was not surprising.

On the (1858) Atlantic Cable the coefficient of retardation appeared to be 414×10^{-9} seconds. On a double suspended line wire between Cincinnati and Pittsburg, Professor Mitchell* found, in 1850, employing an astronomical clock and electro-magnet, that on 607 miles of iron wire a signal took 0·02128 second. Assuming the line resistance at 17 ohms per mile, and the capacity at 0·01 micro-farad per mile, we have, $R = 6{\cdot}07$, $F = 10{,}319$, and—

$$a = \frac{0{\cdot}02128}{10319 \times 6{\cdot}07} = 340 \times 10^{-9} \text{ seconds,}$$

which very nearly agrees with the coefficient deduced from Whitehouse's experiment on the Atlantic Cable.

So does also a long series of experiments made by Gould,† in 1850, on 1045 miles of overhead wire with Morse apparatus. He found the mean time occupied to be 0·086 second. If the line resistance was $17 \times 1045 = 17{,}765$ ohms and the capacity $0{\cdot}01 \times 1045 = 10{\cdot}45$ micro-farads, the coefficient of retardation will have been—

$$a = \frac{0{\cdot}086}{17765 \times 10{\cdot}45} = 377 \times 10^{-9} \text{ seconds.}$$

In the same year, Fizeau and Gounelle‡ invented a very beatutiful method of measuring the velocities of waves, which was intended to overcome the difficulty of *inertia* by the instrument; but it does not appear to be free from this drawback. In this system a rapid succession of periodical currents are sent into one end of the cable and received at the other by two alternate contacts working synchronously with the battery contact, and which direct the electricity in opposite directions through the wires of a galvanometer. When the line has no retardation half of each wave neutralises the effect of the other half, and the galvanometer needle remains undeflected; but when a line is in circuit, the arriving wave being held back will be divided into two unequal parts, and the galvanometer having more current on one side than on the other will be deflected. By regularly increasing the speed a series of maxima and minima deflections are observed, and by noting the speed at two following maxima; that is, the increased speed which is required to put one wave more into the line, the time of a wave travelling from the sending end to the galvanometer may be easily reckoned. With this method it would, at first sight, seem that *inertia* must be eliminated; that this is not so, however, appears from Fizeau and Gounelle's results.

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* "Phil. Trans." 1835, p. 583.

* "Pogg. Ann." lxxx., p. 161.

† "American Journal," 2nd series, xi., p. 67.

‡ "Comptes Rendus," vol. xxx., p. 437.

With this apparatus then found, for example, on a No. 8 B. W. G. iron wire between Paris and Amiens—195 miles long—an apparent velocity of 62,600 miles per second; or that a wave took 0·0031 second to pass through. If this wire had the average resistance and capacity, its resistance would have been about 3315 ohms, and its capacity 1·95 micro-farads; therefore the coefficient of retardation—

$$a = \frac{0·0031}{3315 \times 1·95} = 480 \times 10^{-9} \text{ seconds.}$$

And in a second experiment, the line between Paris and Rouen was used, 179 miles of wire, two-thirds of which was copper, 0·1 inch diameter, the resistance of which was probably 7 ohms per mile, and one-third of a No. 8 iron wire. The total line resistance was, therefore, about 1853 ohms, and the capacity 1·79 micro-farads. The velocity found was 112,680 miles per second, the wave taking 0·0016 second to pass. From this the coefficient of retardation would be—

$$a = \frac{0·0016}{1853 \times 1·79} = 482 \times 10^{-9} \text{ seconds.}$$

In their account of this experiment, Messrs. Fizeau and Gounelle draw particular attention to the greater velocity of the current through copper than in iron wire. The student will, however, see that for unit length and capacity the reduced velocity would be identically the same in both lines, the same apparatus being used. If the high coefficient found from these experiments is due to *inertia* of the galvanometer needle, that would seem to be a less sensitive receiving instrument than an electro-magnet relay; and this is to some extent borne out by Prof. Hughes's experiments.

Fizeau and Gounelle's method was greatly improved on by Guillemin and Bournouf,† in 1854. They employed also a galvanometer, but without the differential method. The cable ends were connected with two contact tongues, which vibrated synchronously between contact anvils. At one end between a + and a − battery; at the other end between earth and the galvanometer, which was also connected to earth.*

An experiment was made by them on the Foix and Toulouse lines, two wires, of each 41 leagues, making together 245 miles of wire. The wave took $\frac{1}{1100}$ second. And assuming the constants of resistance and capacity to be the same as before, the coefficient of retardation would be—

$$a = \frac{1}{1100 \times 4165 \times 2·45} = 89 \times 10^{-9} \text{ seconds.}$$

There is evidently a marked improvement; but still a result only half as good as that given by the mirror galvanometer.

Now these are the results which are generally set down as exceeding discordant, but between which, when rightly interpreted, we find a very remarkable connection. In the following Table I have put them together so that a comparison may be readily drawn between the speeds as generally stated and the deduced coefficients, which is of much more importance for the student to study:—

System.	Observer.	Line.	Length.	Speed in miles per second.	Coefficient 10^9 times a.
Mirror.	Gould.	Cable.	1896 k.	8300	47
Galvanometer.	Guillemin.	Wire.	245 m.	111,700	89
Hughes's.	Clark.	Cable.	462 k.	2870	105
Bain.	Walker.	Wire.	220 m.	19,500	291
Electro-magnet.	Mitchell.	Ditto.	607 m.	28,524	340
Ditto.	Gould.	Ditto.	1045 m.	15,890	377
Ditto.	Whitehouse.	Cable.	1020 k.	816	414
Galvanometer.	Fizeau.	Wire.	195 m.	62,600	480
Ditto.	Ditto.	Ditto.	179 m.	112,680	482
Spark 0·1″	Wheatstone.	Ditto.	½ m.	288,000	870,000

At this date it is, of course, impossible to return to these experiments with any certainty as to the electrical constants of the materials employed. I have, therefore, assumed general average values; and the student will see that even with these how nearly the results accord with each other. Take as an example the experiments made with electro-magnets by different observers on different lines, with different apparatus, and under quite different conditions.

But one thing is certain, viz., that whatever system is used the time required for a wave to get strength enough to overcome the *inertia* of the apparatus is very great in proportion with the time actually occupied between the making of contact at one end of a wire, and the first instant of its arrival at the other end.

In future experiments with improved apparatus and a better knowledge of how to interpret his results, it is open to the student to add valuable information to this branch of the science of electricity.

PAPERS FOR JUNIOR STUDENTS.

The Resistance of Insulators.

THE resistance of the dielectric or insulator presents some of the most important problems of electro-telegraphy, and it will be impossible that we can exhaust their application until we have attained to some acquaintance with instrumental work. But there are general principles the knowledge of which will tend to the easier understanding of what we shall presently have to say. The specific resistance of insulators varies with every variation in their composition; and as their composition is necessarily subject to many more variations than are likely

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Vide L. Clark's "Experimental Investigation," &c., p. 38.

† "Comptes Rendus," xxxix, p. 330.

* They really employed rotatory contacts; but this is the form given subsequently to the apparatus.

to occur with a simple metal, such as copper, the tabulation of a series of resistances would be of little value to the student. Variation in the resistance will occur, too, through difference of age of the insulator, especially if this be india-rubber or gutta-percha; and difference of temperature results in difference of resistance of insulators to a very large amount.

But were these causes of variation eliminated there would remain a very probable source of error in the difficulty of ascertaining how much electricity has passed by the surface moisture or dirt adhering to the insulator. This conduction by the surface of a body it is very difficult to avoid, and for the following reason:—There is an exceedingly large quantity of common salt (or chloride of sodium) floating about, in fine particles, in the air. The perspiration of one's hands contains a large proportion of this ingredient. Now a great deal of this salt is deposited or condensed on the surface of any solid body (as those amongst our students who have worked with a spectroscope will be painfully aware), and as salt is, in relation to an insulator, not such a very bad conductor, a large proportion of the electricity escapes over the surface. Glass, when thoroughly warm and dry, is a very perfect insulator, but in ordinary or moist atmosphere much of the electricity finds its way to earth, and is lost. The ebonite or vulcanite insulators of electrical instruments are very quickly covered with such a conducting film, and Mr. Varley, who has studied the subject extensively, recommends the washing of the surface of the ebonite or vulcanite with very dilute sulphuric acid, then with water, rubbing until dry, when the surface may have solid paraffin rubbed over it.

The presence of this conducting film at once explains how preferable it is to reduce the extent of surface of an insulator, on the ground that by reducing the superficial area we reduce the liability of the electricity to escape. The glass insulators of our telegraph posts are constructed on the principle of exposing as little conducting surface as possible.

It should be remembered that, although there is much difference between what is generally termed a bad conductor and an insulator, the latter does not mean a substance giving infinite resistance, through which no electricity can pass, but simply a *very* bad conductor. Graphite and gas-coke are bad conductors, for their specific resistance is from 1500 to 40,000 times that of pure copper. The resistance of gutta-percha, however, bears very little relation to this, as we may gather from the resistances of a cubic metre of various kinds of gutta-percha employed in the undermentioned cables:[*]—

	B. A. Units of Resistance.
Red Sea	$0{\cdot}362 \times 10^{12}$[†]
Malta-Alexandria ...	$1{\cdot}230 \times 10^{12}$
Persian Gulf	$1{\cdot}800 \times 10^{12}$
Atlantic (2nd)	$3{\cdot}420 \times 10^{12}$
Gutta-percha, at 24° C.	$3{\cdot}530 \times 10^{12}$

For the purposes of comparison it may be stated that the British Association unit of resistance would be measured by a conductor of pure mercury, 1 sq. millim. in section and 1·0486 metres long at 0° C. Of course a cubic metre of copper would have no perceptible resistance.

The most useful information we can give the student as to the nature and character of the principal insulators is to describe what they are, and, as far as known, the method of preparation.

India-rubber.—This well-known substance, sometimes called caoutchouc, is the dried juice of a tree, the trees yielding the juice being known botanically as of the orders *Urticæ*, *Euphorbiaceæ*, *Apocyneæ*, the product of the *Siphonia cahucu* (South America) and of the *Urceola elastica* (East Indies) being known commercially. The native incises the tree, and collects the exuding juice in vessels of dried clay, whence the product takes the form known as "bottle" rubber. The juice is solidified by the application either of artificial heat or of that of the sun; in the latter case the product is known as "lard" gum or rubber. In this way we obtain the immense supply of india-rubber for our cables, the purposes of waterproofing, &c.; as much as 120,000 cwts. having been produced in 1870, 60,000 cwts. of which came from the island of Java.

Pure india-rubber is white, and, when in thin sheets, semi-transparent. Its elasticity is perfect. It is non-fibrous, but it possesses the curious property of becoming somewhat fibrous and less transparent when excessively stretched. It is not brittle when cold, but becomes hard; hot water and steam render it soft, but it suffers no chemical change from their action.

India-rubber is soluble in—
- Alcohol-free ether,
- Oils of caoutchouc,
- ,, turpentine (with heat),
- Sulphide of carbon,
- Persian naphtha,
- Chloroform,
- Benzoline.

It is insoluble in alcohol; is not decomposed by dilute acids or strong alkalies (strong acids readily decompose it). If a piece of india-rubber be stretched and then immersed in cold water it loses some of its elasticity, which it regains when placed in water at 45°. It melts at 200°, and when ignited gives off a gas possessing high illuminating power.

The chemical formula of india-rubber is C_4H_7, and 100 parts of this substance contain 87·5 parts of carbon and 12·5 of hydrogen.

The electrical resistance of inda-rubber decreases with increase of temperature, but not so rapidly as with gutta-percha. Under pressure the resistance increases.

Vulcanite.—India-rubber immersed in molten sulphur becomes subject to several changes,—that is to say, it is vulcanised, and remains elastic (while india-rubber hardens) at very low temperatures. The solvents of india-rubber no longer act upon it. There are several methods of preparing vulcanite, the chief being the following:—Parke's method: The india-rubber is thrown into a mixture of 40 parts sulphide of carbon and 1 part chloride of sulphur, placed in a chamber heated to 21°. The sulphide of carbon is volatilised, and the vulcanised rubber is then washed, first with a dilute solution of caustic potash, and then with water. In Humphrey's method benzoline is substituted for the sulphide of carbon. Many other methods have been devised, but they have not met with extended use.

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[*] Taken from Prof. Jenkin's "Cantor Lectures."

[†] 10^{12} should be read 10 raised to the 12th power, that is, one with 12 noughts after it, or a million times a million.

Ebonite.—Ebonite is vulcanised india-rubber hardened by the use of more sulphur (50 to 60 per cent) and higher temperatures than are employed for vulcanite, together with the addition of gutta-percha, asphalte, pipe-clay, sulphide of zinc, &c. Ebonite is only slightly elastic.

Hooper's India-rubber.—The Hooper Company cover the wire of their cables, first with pure india-rubber; then, subjecting the india-rubber coating to a vulcanising process, the outside becomes hardened, and less susceptible to the action of sea-water than is pure rubber. This compound is much less liable to variation in resistance by increase of temperature than gutta-percha, as the following observed resistances at various temperatures will show:—

Temperature.	Resistance.	
	Gutta-percha.	Hooper's Core.
0° C.	100·0	100·0
10° C.	28·9	58·8
20° C.	8·4	29·1
30° C.	2·9	16·7

Gutta-percha.—Like india-rubber, pure gutta-percha is quite white, and it is also the dried juice of a tree, the *Isonandra gutta.* The term "gutta-percha" is really derived from the Malay language, and signifies "Sumatra gum," the island of Sumatra being known as "Pulo-percha." Gutta-percha will bear great strain (1¾ tons to the square inch), and on this account, especially in a form modified by Mr. Willoughby Smith, has been more extensively employed for telegraphic insulation than any other material. Its solvents are—

Oil of turpentine (with heat),
Sulphide of carbon,
Chloroform,
Oil of caoutchouc,
Coal-tar oils.

It is insoluble in—

Water,
Dilute acids,
Alkalies,
Alcohol.

Gutta-percha and india-rubber absorb water, to the following amount, as given by Messrs. Clark and Sabine:—

	In Fresh Water.	In Salt Water.
...	23·00 per cent.	3·0 per cent.
Unvulcanised ...	19·00 ,,	3·9 ,,
Vulcanised... ...	10·14 ,,	2·9 ,,
Gutta-percha ...	1·50 ,,	1·0 ,,

With regard to electrical resistance the effect of temperature is greater than with india-rubber, while the resistance increases to a considerable percentage under pressure.

Asphalte or Bitumen.—This substance is employed in the manufacture of cables, and is found as a natural product in various parts of the world. An artificial product termed asphalte is obtained from coal-tar, which is sometimes mixed with lime and sulphur. The natural product is also known as mineral pitch.

Clark's Compound.—This insulating material, for the outer casing of the iron sheathing of cables, is stated to be composed of 5 parts by weight of tar, 30 parts of silica, and 65 parts of mineral pitch.

Chatterton's Compound.—Is really a cement, used to lute together the coatings of gutta-percha upon a cable-conductor. It is composed of 3 parts by weight of gutta-percha, 1 part each of resin and Stockholm tar. The insulating power is much less than that of gutta-percha.

Silk, paraffin, resin, &c., it will not be necessary to describe to the student.

Proceedings of Societies.

THE REDE LECTURE AT CAMBRIDGE.

Professor G. P. Tait was the Rede lecturer this term, and had selected as his theme the subject of Thermo-Electricity. Having dwelt upon the importance of Sir W. Thomson's definition of *absolute* temperature, he continued:—The subject of thermo-electricity of course includes all electric effects depending on heat, but in this lecture I shall confine myself to the production by heat of currents in a circuit of two metals.

The transformation of heat into the energy of current electricity was first observed by Seebeck in 1820 or 1821. His paper on the subject (*Berlin Ac.*, 1822-3, or *Pogg. Ann.* vi.) is particularly interesting, as he gives the whole history of his attempts to obtain a voltaic current from a circuit of two metals without a liquid, and the steps by which he was led to see that heat was the active agent in producing the currents he eventually obtained. In this paper Seebeck gave the relative order of a great number of metals and alloys in the so-called thermo-electric series, and showed that several *changes of order* occurred among them as the temperature was gradually raised.

In a note attached to this paper, Seebeck recognises that in this further discovery he was anticipated by Cumming (who seems, in fact, to have made an independent discovery of thermo-electricity). Cumming showed that when wires of copper, gold, &c., were gradually heated with iron, the deflection rose to a maximum, then fell off, and was *reversed* at a red heat.

You see that, keeping one of the copper-iron junctions at the temperature of the room and gradually heating the other, I produce a current which increases in intensity more and more slowly till it reaches a maximum, then falls off faster and faster, till at last it vanishes, and thereafter sets in the *opposite* direction. We are still far below the melting-point of copper, yet further heating up to that point produces but little additional effect. The reason of this will be apparent from some facts to be described towards the end of the lecture. At the moment of maximum current the two metals are thermo-electrically *Neutral* to one another. The temperature in the present case is about 280° C.

Seebeck pointed out that bismuth and antimony (to the choice of which he had been led by a very curious set of arguments) were very far removed from one another in the series, and therefore gave large effects for small differences of temperature. This is still taken advantage of in the thermo-electric pile, which, when combined with a sufficiently delicate galvanometer, is even now by far the most delicate thermometer we possess. It has recently enabled astronomers to detect and measure the heat which reaches us from the moon, and even from the brighter fixed stars. In the skilful hands of Forbes and Melloni this instrument was the effective agent in demonstrating the identity of thermal and luminous radiations—a step which, as regards the simplification of science, is as important as the discovery of magneto-electricity; and which was completed by Forbes when he succeeded in polarising radiant heat.

But when we come to look at this question from the point of view of transformation of energy, we have to ask *where* is the absorption, and *where* the letting-down of the heat, to which the development of the current considered as a rise of energy is due. Very remarkably, an experiment of Peltier supplies us with at least part of the answer. Peltier showed that, given a metallic junction which, when heated, would give a current in a certain direction, then provided a battery were interposed in that circuit (initially at a uniform temperature) so as to send a current in that direction, the passage of the current *cooled* the junction, while a reversal of the current heated it. This, considering the circumstances under which it was made, and the deductions since drawn from it, is one of the most extraordinary experimental discoveries ever made. Water was frozen, in an experiment by Lenz, by means of the Peltier effect.

Here then is a reversible heat effect, and to it we may reasonably assume that the laws of thermo-dynamics may be applied; although from the very nature of the experiment the reversible effect must always be accompanied by non-reversible ones, such as dissipation by heat-conduction and by heat generated in consequence of the resistance of the circuit. The latter of these is in general small in thermo-electric researches, but the former may have large values.

It is known from the beautiful experiments of Magnus that no thermo-electric current can be produced by unequal heating in a homogeneous circuit, whatever be the variations of section—a negative result of the highest importance. Sir W. Thomson, to whom we are indebted for the first and most complete application of thermo-dynamics to our subject, showed that the existence of a neutral point necessitates the existence of some other reversible effect besides that of Peltier. And even if the circuit varied in section, the result of Magnus, just referred to, showed that this could only be of the nature of a convection of heat by the current between portions of the same metal at different temperatures. Thomson's reasoning is of the very simplest character as follows:—Suppose the temperature of the hotter junction to be that of the neutral point, there is no absorption or evolution of heat there; yet there is evolution of heat at the colder junction, and (by resistance) throughout the whole circuit. The energy which supplies this must be that of the heat in one or both of the separate metals; but reasoning of this kind, though it proves that there must be such an effect, leaves to be decided by direct experiment what is the nature and amount of this effect in each of the metals separately. By an elaborate series of ingenious experiments Thomson directly proved the existence of a current convection of heat, and (curiously enough) of opposite signs in the first two metals (iron and copper) which he examined. In his own words, "vitreous electricity carries heat with it in an unequally heated copper conductor, and resinous electricity carries heat with it in an unequally heated iron conductor." This statement is not very easy to follow. It may perhaps be more intelligible in the form:—In copper a current of positive electricity tends to equalise the temperature of the point it is passing at any instant with that of the point of the conductor which it has just left, *i.e.*, when it passes from cold to hot it tends to cool the whole conductor; when from hot to cold, to heat it, thus behaving like a real liquid in an irregularly heated tube. The effects in iron are the opposite; and Thomson therefore speaks of the specific heat of electricity as being thus positive in copper and negative in iron. He gives a very remarkable analogy from the motion of water in an endless tube (with horizontal and vertical branches), produced by differences of density, due to differences of temperature. Here the maximum density of water plays a prominent part. Neumann has recently attempted, by means of the laws of motion of fluids, and the unequal expansibility of different metals, to give a physical explanation of thermo-electric currents. But, not to speak of the fact that positive electricity is by him considered as a real fluid, there are the fatal objections that his method makes no provision for the explanation of the Peltier, or of the Thomson effect; and therefore cannot be looked upon as having any useful relation to the subject. Similar remarks apply to the attempt of Avenarius to account for thermo-electric currents by the variation with temperature of the electrostatic difference of potentials at the points of contact of different metals.

By employing the thermo-electric pile instead of the thermometers used by Thomson, Le Roux has lately measured the amount of the specific heat of electricity in various metals, and has shown that it is very small, or altogether absent, in lead. Strangely enough, though he has verified Thomson's results, he does not wholly accept the theoretical reasoning which led to their prediction and discovery.

One of Thomson's happiest suggestions connected with this subject is the construction of what he calls a thermo-electric diagram. In its earliest form this consisted merely of parallel columns, each containing the names of a number of metals arrranged in their proper thermo-electric order for some particular temperature. Lines drawn connecting the positions of the name of any one metal in these successive columns indicate how it changes its place among the other metals as the temperature is raised. Thomson points out clearly what should be aimed at in perfecting the diagram, but he left it merely as a preliminary sketch. The importance of the idea, however, is very great; for, as we shall see, the diagram when carefully constructed gives us not merely the relative positions of the metals at various temperatures, with the temperatures of their neutral points, but also gives graphic representations of the specific heat of electricity in each metal in terms of the temperature, the amount of the Peltier effect, and the electromotive force (and its direction) for a circuit of any two metals with given temperatures of the junctions. In short, the study of the whole subject may be reduced to the careful drawing by experiment of the thermo-electric diagram, and the verification of Thomson's thermo-dynamic theory will then be effected by a direct determination either of Peltier effects or of specific heat of electricity at various temperatures, and their comparison with the corresponding indications of the diagram.

The diagram is constructed so that abscissæ represent absolute temperatures, and the difference of the ordinates of the lines for any two metals at a given temperature is the electromotive force of a circuit of these metals, one of the junctions being half a degree above, the other half a degree below, the given temperature.

It will be seen by what follows that nothing but direct measurement of the value of the specific heat of electricity at various temperatures can give us the actual form of the line representing any particular metal; but if the line for any one metal be assumed, those of all others follow from it by the process of differences of ordinates just described. So that it is well to begin by assuming the axis of abscissæ as the line for a particular metal (say lead, in consequence of Le Roux's result); and if, at any future time, this should be found to require change, a complex shearing motion of the diagram parallel to the axis of ordinates will put all the lines simultaneously into their proper form.

For the benefit of such of my audience as are not familiar with mathematical terms, I may give an illustration which is numerically exact. Let time stand for temperature, years corresponding say to degrees. Let the ordinate of one of the metals represent a man's income, that of the other his expenditure. The difference of these ordinates represents the rate of increase of his capital or accumulated savings, which here stands for electromotive force. As long as income exceeds expenditure, the capital increases; when income and expenditure are equal (*i.e.*) at a "neutral point," capital remains stationary, indicating, in this case, a maximum value; for in succeeding years expenditure exceeds income, and capital is drawn upon.

Guided by considerations of dissipation of energy, I was led some years ago to the hypothesis that specific heat of electricity must be, like thermal and electric resistance, directly proportional to the absolute temperature. If this were the case, the lines in the diagram would be straight for all metals; and parabolas would be the graphic representation not only of electromotive force, but of the Peltier effect, in terms of the temperature of a junction. And I found by actual measurement of curves plotted from experiment, that, within the range of mercury thermometers, the curves of electromotive force for junctions of any two of iron, cadmium, zinc, copper, silver, gold, lead, and some other metals, are parabolas with their axes vertical; the differences from parabolas being in no case greater than the inevitable errors of experiment and the deviation of mercury thermometers from absolute temperature. If, then, the line for any one of these metals be straight within these limits of temperature, so are those of all the others. This makes the tracing of the diagram within these limits a very simple matter indeed. And an easy verification is furnished by the fact that from the parabolas for metals A and B, and A and C, we can draw the lines for B and C, assuming any line for A; and we can then compare the temperature of the intersection of these lines with that of the neutral point of B and C as found directly. Another verification is supplied by the tangents of the angles at which these parabolas cut the axis of abscissæ, for the sum of two of them ought in every case to be equal to the third.

Endeavouring to extend the investigation to temperatures beyond the reach of mercury thermometers, I worked for a long time with a small air-thermometer, of which the principle was suggested to me by Dr. Joule. But this involved very great experimental difficulties, due mainly to chemical action at high temperatures; and, after much unsatisfactory work, I resolved to make one thermo-electric junction play the part of thermometer in observing the indications of another. In fact, an exceedingly elegant result follows at once from the preceding formulæ, if we suppose the specific heat of electricity to be proportional to the absolute temperature in each of four metals, and then draw a curve whose ordinate and abscissa are the simultaneous galvanometric indications of pairs of these metals, with their hot and cold junctions respectively at the same temperatures. For if τ be the difference of absolute temperature of the junctions, we have—

$$x = A\tau + B\tau^2$$
$$y = C\tau + D\tau^2$$

where the four constants depend upon the nature of the metals and upon the absolute temperature of the cold junction. These equations give—

$$(Dx - By)^2 = (CB - AD)(Cx - Ay)$$

which is the equation of another parabola, also passing through the origin, but with its axis no longer vertical.

A simple proof of this theorem is furnished by the motion of projectiles *in vacuo*. Suppose a particle to move under gravity, and subject, besides, to another constant force parallel to a given horizontal line—its path would have both ordinate and abscissa parabolic functions of the time. But its path might also be found by compounding into one the two accelerations, and as each of these is constant in direction and magnitude, their resultant will have the same property, and thus the resultant path is a parabola. Tried in this way through ranges of temperature up to a red heat, I found that while some pairs of circuits gave excellent parabolas, others were far from doing so, sometimes in fact giving curves with points of contrary flexure. I was on the point of recurring to the air-thermometer, when I noticed that in nearly every case in which the curve was not a parabola, iron was one of the metals employed; and, by the help of some alloys of platinum, I was enabled to get an idea of the true cause of the anomaly, and afterwards to verify it by an independent method. The cause is this, that while, as Thomson discovered, the specific heat of electricity in iron is *negative* at ordinary temperatures, it becomes *positive* at some temperature near low red heat; and remains positive till near the melting-point of iron, where it appears possible, from some of my experiments, that it may again change sign. Thus the line for iron, straight at ordinary temperatures, passes downwards from the first quadrant to the fourth, and thence rises into the first again.

To recur to our analogy, an income represented by the iron line is one which for a number of years steadily diminishes, reaches a minimum, and then steadily increases. If this be associated with a steady expenditure, the fluctuations of capital will depend upon the comparative values of the expenditure and the minimum income. If the expenditure be less than the minimum income, the capital will go on increasing slower and slower to a certain point, then faster and faster; there will be no stationary point, but there will be a point of contrary flexure. If the expenditure be just equal to the minimum income, the point of contrary flexure will be also a stationary point. If the expenditure be greater than the minimum income there will be a maximum of capital, then a point of contrary flexure, and then a minimum; the maximum and minimum being the stationary points corresponding to the two occasions on which the expenditure equals the income. The maximum and minimum will obviously be farther apart, and smaller, the larger is the expenditure compared with the minimum income.

The latter part of these statements is well exhibited by the behaviour of circuits of iron, and various alloys of platinum with iridium, nickel, and copper.

In each of these cases there are obviously two neutral points at least. Now, suppose the two junctions raised to the temperatures of these two neutral points respectively, and we have a thermo-electric current maintained *entirely* by the specific heat of electricity, as there is obviously neither absorption nor evolution of heat at either junction. Still further, suppose (as is *very nearly* the case with one of the alloys I have just used) that the specific heat of electricity is *null* in the metal associated with iron, and we have the very remarkable fact of *a current maintained in a circuit, without absorption or evolution of heat at either junction or in one of the metals, but with evolution of heat in one part of the second metal and absorption in another part.* This suggests immediately the idea that iron becomes, as it were, a different metal on being raised above a certain temperature. This may possibly have some connection with the ferricum and ferrosum of the chemists; with the change of magnetic properties of iron, and of its electric resistance, at high temperatures. Dr. Russell has kindly enabled me to verify these properties in a specimen of pure iron prepared by Matthiessen. I find similiar effects with nickel at a much lower temperature. The method of control which I employed to satisfy myself that these peculiarities are due to iron and not to the platinum alloys, requires a little explanation. It depends upon the fact that by the help of two metals made into a double arc (wires of the two being stretched side by side without contact except at the ends) we can explore any portion of the field between the lines for these two metals by simply altering the ratio of the resistances in the two parts of the double arc. Such a complex arrangement gives a line passing through the intersection of the lines of the two constituents, and depending for its position on their relative resistances. I shall not, at this stage of my lecture, trouble you with the formula which gives the line for the double arc in terms of the resistances of the two metals and their lines, but simply show the experiments with the help of a gold and a palladium wire, the one having the specific heat of electricity positive, the other negative; while their neutral point is considerably below the temperature of the room. Between their lines is included the peculiar portion of the iron line, and by making shots at it, as it were, in various directions from the neutral point of gold and paladium, we shall be able to study its bearings.

I have here wires of iron, gold, and palladium, bound together at one end, which is to be the hot junction. One end of the galvanometer coil is connected with the free end of the iron wire, the other slides along a long copper wire, which connects the free ends of the gold and palladium wires. By sliding it towards either I diminish the resistance of that branch of the double arc and increase that in the other, *i.e.*, I give that branch of the double arc the greater importance in the combination.

Throwing the greater part of the resistance into the palladium branch, I find a neutral point at a moderate temperature, but I cannot reach a second without melting the gold. Throw more resistance into the gold, the first neutral point occurs at a higher temperature than before, but a second is attainable. By still further increasing the resistance in the gold the two neutral points gradually approach one another, one rising in temperature, the other descending, until at last we reach the maximum-minimum, the result of the confluence of the two points. The line for the double arc is now such as to *touch* the iron line. Still further increase the resistance of the gold, and we find a mere point of inflexion, the galvanometer indications having constantly *risen*, though at a retarded and then accelerated rate, during the heating of the junction.

Two of the platinum alloys which I employed with iron seem to give lines almost exactly parallel to the lead line, *i.e.*, in them the specific heat of electricity is practically *nil*. When a circuit is formed of these alloys the current therefore depends upon the Peltier effects at the junctions alone, and is sensibly proportional to the difference of their absolute temperatures, thus furnishing a very convenient thermometer for the approximate estimation of high temperatures. I am at present engaged in drawing the thermo-electric diagram in terms of temperatures as given by this combination, and the reduction to absolute temperatures will finally be effected by a comparison of this temporary but very convenient standard with an air-thermometer.

ROYAL SOCIETY OF STOCKHOLM.

Recently a paper was read before this Society by M. E. Edlund, entitled "*Researches on the Nature of the Resistance to Conduction of the Galvanic Current and Theoretical Deduction from Ohm's Law and Formula for the Development of Heat by the Galvanic Current.*" In the introduction to this paper the author refers to the fact that, as revealed by the researches on light, the ether possesses a greater density in material substances than *in vacuo;* hence all substances are endowed with the power of attracting and condensing ether, and this condensation continues until the attraction of the molecules of matter and of a molecule of ether beyond it is equally great. The ether theory is further applied for the purpose of explaining the phenomena of the galvanic current, which, according to the author, consists in the transport of the free ether along the galvanic conductor as fully set forth in a separate memoir published by the author (*Archives des Sciences Phys. et Nat. Geneve*, 1872). As regards the resistance to conduction, the author views electricity as a fluid, the particles of which are very mobile, and capable of conveying pressure equally in all directions. The resistance of conduction opposes the motion of the electric fluid, and acts, therefore, as a counter pressure (*Gegendruck*), which is again equally strong in every direction. When, for instance, two metallic wires of the same thickness, but of different metals, exhibit an equal decrease of a given electric current, we say that the resistance is in each wire the same, and consequently the counter pressure in each case equal also. This subject is further elucidated by a series of formulæ and diagrams, too many and complex to be here quoted. As regards the deduction from Ohm's law, the author observes that in this, as in other particulars, it has been assumed that the electric fluid, contrary to all analogy with all other matter, differs in its properties, and is wanting the *vis inertiæ*. It is pointed out that it is not warrantable to ascribe to electricity properties contrary to those of the general nature of matter.

NATIONAL ACADEMY OF SCIENCES, CAMBRIDGE (MASS., U.S.A.).

A paper "*On the Effects of Magnetisation in Changing the Dimensions of Iron, Steel, and Bismuth Bars, and in Increasing the Capacity of Hollow Iron Cylinders*" (Part I.), was read recently by Dr. Alfred M. Mayer, Professor of Physics in the Stevens Institute of Technology, Hoboken, New Jersey, U.S.A. In a series of these papers Prof. Mayer purposes giving the results of a long and careful research on the subject. He first includes an account of Joule's researches to this end, with the important law deduced by Joule, "that the elongation is in the duplicate ratio of the magnetic intensity of the bar, both when the magnetism is maintained by the influence of the coil, and in the case of the permanent magnetism after the current has been cut off;" and that in studying the effect of tension on the phenomena (or the wire being submitted to strain), "the shortening effect is proportional to the current traversing the coil multiplied by the magnetic intensity of the bar," or "proportional *cæteris paribus*, to the square root of the force of the tension." Remarking on the cause of the phenomena of elongation, Dr. Joule says:—"The law of *elongation* naturally suggests the joint operation of the attractive and repulsive forces of the constituent particles of the magnet as the cause of the phenomena. On the other hand, the fact that the *shortening effect* is proportional to the magnetic intensity of the bar multiplied by the current traversing the coil seems to indicate that in this case the effect is produced by the attraction of the magnetic particles of the coil. But then it will be asked why so remarkable an augmentation of the effect is produced by the increase of tension in the case of the soft iron bars. When we are able to answer this question in a satisfactory manner, we shall probably have a much more complete acquaintance with the real nature of magnetism than we at present possess." Thence Dr. Mayer passes to the consideration of the works of Page, Delezeune, De la Rive, Beatson, Marrian, and Wertheim, and, finally, to the researches of Dr. Tyndall.

Adhesive Stamps for Prepayment of Telegrams.—The Austrian Minister for Trade has given notice of his intention very shortly to adopt the system of adhesive stamps for the prepayment of telegrams, and at the same time to reduce the charge for messages, from one station in the Austro-Hungarian Monarchy to another, to one uniform rate of fifty kreutzers.

Electrical Science in Foreign Journals.

(We intend to devote this column to a list of Electrical Memoirs published in Foreign Journals during the month. Those of importance will be either translated in full or given in abstract.)

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences, Vol. lxxvi., No. 20.

Further Observations concerning the Influence of Metallic Deposits upon Zinc in the Presence of Acids and Alkalies.—By M. C. Gourdon.—[A chemical paper essentially, but containing some remarks interesting to the electro-chemist, which we quote.] The labours of M. Merget (*Comptes Rendus*, 1863) have shown that zinc, covered by precipitation with another metal, is attackable by dilute nitric acid at those points uncovered, whilst in sulphuric, hydrochloric, and acetic acids, diluted, it is, on the contrary, attacked only at those points where the foreign metal covers it. In following out these experiments, M. Gourdon has discovered some new and interesting facts. With zinc upon which platinum has been deposited in a powder from the bichloride it is possible to determine the action upon the zinc, at the point of contact with the platinum, with sulphuric acid diluted with 7000 volumes of water. If we replace platinum with gold, sulphuric acid diluted with 5000 times its volume of water will affect the zinc. Copper, similarly, with the acid diluted to 4000 volumes; silver, 3500; tin, 1000; antimony, 700; bismuth, 500; lead, 400. With mercury the results are uncertain. Salts of the same base, with different acids, are not identical in their behaviour. Chlorides give more energetic deposits than sulphates, and these more than the nitrates. Alkaline salts, by the addition of a small quantity of ammonia, yield a more rapid deposit than the same salts employed alone. The intervention of electricity alone appears to M. Gourdon insufficient to explain the phenomena.

On an Electro-Diapason.—A second note by M. E. Mercadier.—Having proved the exactitude of his instrument by a series of experiments, M. E. Mercadier seeks to increase the amplitude of its vibrations, and finds that the amplitude depends upon the form of the diapason, the distance of the branch of the fork from the electro-magnet, the height of the electro-magnet, the intensity of the current, and, finally, upon the nature and length of the style.

On the Various Electric Movements observed on an Interrupted Lightning Conductor at Greenwich Observatory.—By M. W. de Fonvielle.—On the interrupted lightning conductor at Greenwich Observatory has been mounted an electrical tourniquet, with movable arms and a compensator, that M. de Noaillon and myself have combined in order to obtain a measure of the natural currents produced during storms. This tourniquet was in use from the month of September to December last. We have suspended our needle upon a pivot (1 c.m. in height) fixed at the centre of a copper disc, in communication with the aërial band of the broken conductor. As shown in Mr. Glaisher's Report, the needle has been found subject to oscillatory movements when suspended excentrically. Equilibrium was obtained by the aid of a compensating ball. If the pivot of a tourniquet of which the arms are equal be placed excentrically, and the copper circle be placed in communication with an electric machine in motion, the needle will take a pendulous movement. The inequality in length of the arms produce at Greenwich the same effect as the defect of symmetry in the excentric conducting plate with relation to the pivot. It is then proved that all points of the disc act in the same manner on all points of the tourniquet, whether the electricity be due to the lightning-conductor or a machine. The deductions are confirmed by an observation due to M. Ruhmkorff. We know that a mica disc, moving around a pivot, turns whilst we present it to the conductor of an electric machine; but we ignored, before M. Ruhmkorff observed the fact, that the rotation changes its direction when we pass to the other extremity of the conductor. The necessity for this inversion is evident, if we admit that all points of the electrified surface act on all points of the surface influenced, because, if the electric machine is to the right of the disc, it tends to draw the disc towards itself, and the disc turns consequently from left to right. The rotation will be in inverse direction if we place the disc of mica at the other extremity of the machine. If we place the disc in the intermediate line it will turn one direction or the other, determined by the most feeble differences of action. It will be immovable if the pivot is rigidly vertical, the conductor being rigidly horizontal.

No. 21.

On the Conditions of Maximum Magnetic Effect in Galvanometers and Electro-Magnets.—By M. J. Raynaud.—The question of the resistance attributed to a galvanometer or an electro-magnet, in order to obtain the maximum effect corresponding to an electromotive force and a given exterior resistance, may be viewed in two ways: we can propose to determine the thickness of the coil, that is to say the number of turns that may be made round the frame, in order to utilise as much as possible a wire of *given diameter*, or to determine the diameter of the wire to be employed, so as to utilise as much as possible *a given weight of copper*. The two problems may be put into equations to obtain a common expression for the magnetic effect, which, in the particular case treated by M. du Moncel (*Comptes Rendus*, p. 369), is represented by—

$$\mathrm{F} = \frac{a\mathrm{E}abg^2}{g^4\mathrm{R} + ab[(a+c)\pi + 2d]}.$$

It is therefore not exact to say, as does M. du Moncel, that we are wrong in supposing, in the second problem, that the number of turns is proportional to the square root of the resistance of the coil. This proportionality is true in the two cases. The expression for F may therefore be differentiated, either in relation to the thickness a or in relation to the diameter g. In the first hypothesis, the condition of maximum is that the bobbin should have a resistance greater than the exterior resistance, by a quantity $\frac{ab}{g^4}(\pi c + 2d)$, representing the resistance of a length of $t = \frac{ab}{g^2}$ turns of the first layer. In the second hypothesis, the resistance should be equal to the exterior resistance, and even—in taking into account the thickness of the silk—*inferior* to the exterior resistance, in the relation of the radius of the wire to the increased radius of this thickness. It is of consequence to remark that an electro-magnet, constructed from the conclusions of the first hypothesis, will have a magnetic effect *less* than an electro-magnet constructed with the same amount of copper, but with a wire of greater diameter, so as to attribute to it the resistance which will make it agree with the second hypothesis. In the construction of delicate galvanometers, such as that of Sir W. Thomson, the diameter of the wire may be taken as proportional to the distance of the layers of wire from the axis.

Researches on Electricity produced in Mechanical Actions.—By M. L. Joulin.—*New Electrical Machines.*—The electric phenomena observed on the straps for transmitting motion have led us to construct new electrical machines, with which we have re-commenced the study of the development of electricity by mechanical actions. These machines are formed of a strap and two pulleys; the axle of the motion pulley rests on fixed centres; that of the moving pulley turns in centres, which are susceptible of movement under the influence of more or less powerful taction. We have employed, as pulleys, cast-iron, copper, zinc, wood, leather, hardened caoutchouc, wool, and silk; as straps, differently prepared leather, covered with friable coatings, such as tallow, resin, oxides, silk and wool, and gutta-percha. The effects of the electricity of the strap are very powerful: a brass ball of 0·005 m.m. in diameter becomes luminous to a distance of 0·35 m.m.; the sparks are nearly 0·01 m.m. in length; the continuous current notably deflected the needle of a galvanometer, and decomposes water: in Geissler's tubes the electric light is clearly stratified. M. Joulin goes on to consider the distribution of electricity on different parts of the machine, and the phenomena produced by conducting pulleys and non-conducting pulleys. He also proceeds to show how the permanent electric state is established on the machine.

On the Electric Balance, and on an Electroscopic Phenomenon.—Note by M. P. Volpicelli.—The proof plane and Coulomb's electric balance are the means by which physicists, in the present state of the science, inquire experimentally into the laws of electricity in equilibrium. I have already considered (*Comptes Rendus*, vol. lxxiv., p. 860) the use of the proof plane, and the value which we should attribute to the results which it furnishes: I purpose to study, in the present note, the indications of Coulomb's balance and their value. Plana and Murphy have shown, by higher analysis, that the character of the elementary electrostatic action is in inverse ratio to the square of the distance. Hausksbée, Taylor, Dufay, and Muschembroeck tried, without success, to verify this law by experiment. Later, after Coulomb had applied his torsion balance to this inquiry, many physicists discovered, with him, that the law was exact; but Volta, Configliacchi, Harris, Parrot, Kämtz, Simon, Yalin, Gerbi, Ghevardi, and many others, declared that it was not clearly demonstrated. M. Becquerel showed the necessity of submitting the views of Harris to new experimental proofs ("Traité de l'Electricité et du Magnetism," 2nd part, vol. v., p. 86). Whatever may be the law of electric action revealed by Coulomb's balance, it is certain that this law depends on all the causes or forces which contribute to produce the same action represented by the force of torsion. It results from this that the elementary law of electrostatic action, whatever it may be, which is revealed by Coulomb's balance, should be attributed to the resultant of all the component forces, relative to these disturbing causes which always act, and not alone to the direct attractive or repulsive components. It also results from this that the two inquiries, the one mathematical and the other experimental, for this law, are not comparable, for the first only determines the simple direct action, whilst the second shows the resulting effect of all the electric actions which, in Coulomb's balance, accompany the direct action. I also wish to say a few words, in this note, of a phenomenon which has been described (*Les Mondes*) as follows:—"We touch the knob of a gold-leaf electroscope with a stick of vulcanised caoutchouc, having been negatively electrified by rubbing it with a cat's skin; we remove the skin. If we now approach to the knob of the electroscope a negatively electrified body we find the divergence of the leaves diminish. This phenomenon would be inexplicable if the electroscope were negatively charged: the experiment proves, therefore, that after the removal of the stick there remained an excess of the positive fluid." This conclusion is very true; it is equally verified by the electrophorus; but we must determine the cause of this excess of positive electricity, and describe the remarkable consequences resulting from this phenomenon, and which is shown still better by applying to the centre of a metallic disc two electrometric gold leaves. We should remember that it has been shown by an Italian physicist, M. Marianini, that the electrified dielectrics, placed in contact with the metals, do not communicate to them sensible electricity. It follows from this that the electricity cannot flow on the dielectrics; but, if we interpose a damp stratum between the metal and the dielectric, the communication may be made. It is for this reason that, in the phenomenon in which it acts, we are not able to prove the existence of electricity on the dielectric, but only the induced electricity on the metallic knob of the electroscope. Therefore the gold leaves should be charged, by induction, with free negative electricity, whilst the knob, on the other hand, is charged with positive electricity. But although the former only may be dispersed, and not the second, which is deprived of tension, if we remove the inducing body from the metallic knob the positive electricity should become entirely liberated, and in part neutralised by the whole of the remaining negative charge. In consequence of which there should remain in the leaves a free positive charge, which causes them to diverge. It is for this reason that, if we again approach the same dielectric already electrified negatively, the divergence of the leaves should be diminished, as the experiment has shown. Moreover, the longer we leave the dielectric on the knob the greater will be the second positive divergence of the leaves; but if we remove slowly the dielectric, we shall find the primitive divergence diminish little by little, until it entirely disappears, because the positive will be in part successively set free, and will neutralise at the same time all the negative. When we do not remove the dielectric the remainder of the positive electricity becomes free, and the leaves are again repelled. There are therefore, in this phenomenon, two maxima and one minima of divergence, and we also find here the demonstration that the induced electricity of the first kind, which in this case is the positive, possesses no tension, but regains it as the influence diminishes, and, in this case, I have called it *electricité d'abandon* (*Comptes Rendus*, vol. xli., p. 553). It is plain, by this phenomenon, that the induced electricity of the first kind is not dispersed during the time that it remains under the same influence. This want of dispersion and tension is clearly apparent in the actual phenomenon, and is equally verified by the dry pile electroscope. When we interpose damp paper between the metal and dielectric, the gold leaves are charged by communication and not by induction; in consequence of which, in this case, the phenomenon indicated does not take place.

Les Mondes. Vol. xxxi., No. 2.

On the Nature of Electrcity.—By M. E. Edlund.

No. 3.

On Magnets.—By M. Jamin.—A note, the substance of which has already appeared in these columns.

An Electro-Dynamic Experiment.—By MM. Gaston-Planté and A. N. Breguet.—In charging a secondary couple with plates of lead by means of Gramme's magneto-electric machine, we have observed a phenomenon offering a rather curious example of reciprocal transformation of mechanical work into electricity, and of electricity into mechanical work. Gramme's machine possesses, as is known, the property of furnishing induced currents in the same direction, and the secondary couple is charged with the aid of this machine as if under the influence of a voltaic arrangement, and permits of the obtaining at the end of some minutes, in consequence of the chemical action accumulated on a large surface, temporary effects surpassing those given by the machine in the ordinary manner. But, if in place of discharging the secondary couple we allow it to remain in communication with the machine, and if we cease to turn, if we stop completely, by opposing sufficient resistance, the machine, under the influence of the secondary couple, re-continues the motion, not in an opposite direction, but in the same direction as when charging the secondary couple. The velocity is less, it is true, than that by which the electricity was developed, but it is great and lasts for two or three minutes, that is until the secondary couple is discharged. If we measure the forces put into play, it evidently must occur that the restitution should not be complete on account of the inevitable loss in the transformation. But the loss is very small. The direction of rotation communicated to the machine by the discharge of the secondary couple is, as we have stated, the same as that in which the machine was turned to charge the couple. Now, if the machine, by turning in a determined direction, has charged the couple, it is difficult to conceive at first sight, that under the influence of the discharge of the couple it should still turn in the same direction, for it would appear that the apparatus is charging and discharging at the same time. Nothing seems more paradoxical. The fact, however, is easy of explanation. If we consider the direction of the current furnished by the machine, that of the current given back by the secondary couple, which is inverse to the preceding, and if we take into account the actions which results, we shall find that according to the laws of induction and of electro-dynamics, the movement of rotation should be in the direction indicated by experiment. And, if we observe that the secondary couple has an intensity temporarily superior to that furnished in a given time by the machine, we shall easily be able to perceive that the discharge from the secondary couple overcomes that of the machine. It should be remembered that the experiments are as easily performed with small as with large models of Gramme's machine.

American Journal of Science and Arts. Vol. v., No. 28.

On a Simple Device for Projecting on a Screen the Deflections of the Needles of a Galvanometer, and thus obtaining an Instrument convenient in Research, and suitable for Lecture Experiments.—By Alfred M. Mayer, Ph.D.—The instrumental problem of obtaining on a screen the deflections of a galvanometer in magnified proportions has occupied the thoughts of several physicists. The subject is evidently one of considerable importance. In delicate researches it is often necessary that the body of the observer should be removed from the instrument, while at the same time he must be able to observe the minute deflections of its needles. In lectures before our college classes many of the most interesting and fundamental phenomena of radiant heat, electricity, and magnetism are generally either entirely omitted, or imperfectly presented, in default of an instrument which can be constructed by any one at a small outlay of time and expense. The problem, therefore, has not been deemed below the serious attention of eminent investigators; and although there are some who consider such contrivances as trivial, yet I imagine they would think otherwise if they had the habit of continual original investigation, or the proper ambition to address their students in the very language of Nature, by bringing them face to face with those phenomena which form the sure foundation of our scientific reasoning. The method invented by Poggendorff, of observing the deflections of the galvanometer by reflecting to a screen a beam of light from a small mirror attached to the needles, has been used for many years. Sir William Thomson and Prof. Tyndall have extensively used this method; and it has the advantage of giving to the reflected beam an angular motion the double of that given to the mirror by the needles. More recently Tyndall has devised an instrument based on the principle of the megascope. He throws a vertical beam from an electric lamp on to the dial and needle of the galvanometer, and, by means of a lens and inclined mirror placed above them, he obtains their images on the screen. This kind of instrument is of limited application when compared with the very simple apparatus I am about to describe. The galvanometer has a vertical glass shade, on which are drawn in India-ink the vertical graduation lines of the instrument. The needles are fixed to the lower end of a piece of aluminium wire, whose upper end is perforated with a small hole, so that the system may be suspended by a silk fibre. A fine wire of German-silver is attached transversely to the aluminium wire, and has its ends bent downward at right angles to its length. This transverse wire can be placed at any azimuth by rotating it around its centre, which is coiled two or three times around the vertical aluminium wire. On one of the bent ends of the transverse wire is cemented a diamond-shaped piece of light paper or foil, and the other end carrries a small ball of wax as a counterpoise. The diamond courses round the shade at about 1 m.m. from its interior surface, with its lower point just above the lines of graduation. A beam from the lime-light lantern is thrown upon the graduated side of the shade, and the rays are condensed by an objective upon the opposite side of the shade and projected on the screen. The scale thus thrown upon the screen is not graduated into equal angular divisions, but its units represent units of deflecting force traversing the galvanometer; and this scale is derived from a careful calibration of the instrument. The sharpness of the image on the screen is admirable, and with the calcium-light is distinctly visible in a room considerably illuminated with daylight. With less illumination of the room I have used the instrument when the calcium-light was replaced by a kerosene flame. Evidently the precision of the indications of the apparatus just described are vitiated by the parallax of the index, for it does not describe a cylinder, which is an extension of the one on which are drawn the graduations. This error is avoided by cementing on the inside of the shade a curved piece of glass, whose radius of curvature equals the arm carrying the index, and whose centre coincides with the axis of aluminium wire. With this modification in the apparatus we have succeeded in reading with precision deflections to 6′ of arc. By the following arrangement deflections to 1′, in an arc extending 5° each side of the 0° point, can be determined. A thin slip of microscope cover-glass is coated with a layer of black varnish, and through this varnish are cut, in a dividing engine, fine equidistant lines. The diamond-shaped pointer is replaced by a light of cover-glass, also coated with varnish, and having cut on it one fine vertical line. These lines are illuminated by the lantern, and in front of them is placed an inch or an inch and a half objective. On the screen we have the graduations as a series of bright lines on a dark ground, and along them moves the bright index-line of the pointer. My experience with this instrument has led me to prefer the use of only one magnetic needle—the one enclosed in the coil of the galvanometer—and this needle I render more or less astatic by means of a damping magnet placed above the galvanometer, and sliding on a vertical rod, and rotating on its centre around the same. By means of the magnet one can, with expedition, adapt the sensitiveness of the instrument to the requirements of special experiments, and thus the instrument is admirably suited for all experiments in radiant heat, electricity, or magneto electricity. One might suppose that the heat from the source of light would cause currents of air in the shade, and make the needle fluctuate; but I have not met with this difficulty, and if it should arise it can be removed by placing in front of the condensing lenses a glass tank, containing a solution of alum.

City and Commercial Notes.

The amalgamation of the Anglo-American, the French Atlantic, and the Newfoundland Telegraph Companies is now completed, all the agreements having been duly executed. Of the late directors of the French Atlantic Company, Viscount Monck, Lord William Hay, Baron Reuter, Baron Emile d'Erlanger, the Marquis de Beaumont, Mr. C. Crapelet, and Mr. Edward J. Halsey have been elected upon the Board of the Anglo Company, with Mr. Cyrus Field and Sir James Anderson, late directors of the Newfoundland Company. The transfer books of the Anglo-American Company will be closed on the 1st of July for the purpose of allotting the bonus stock, which will carry dividend from 1st May; the books of the Newfoundland Company are closed, and will not be re-opened, and the liquidation of the French Company will proceed rapidly. The result of the distribution of the increased stock will be that the Anglo Company's shareholders will receive about £152 for each £100, and the French shareholders about £180 for each £100, plus a cash distribution equal at least to 8s. a share, which, together with the quarterly interim dividend of the 1st of May last, will represent a payment for the first four months of the year at the rate of 12 per cent per annum. The Newfoundland Company will receive at once, and in any case, £100 for each £100, any further distribution, exclusive of the proceeds of their land rights, to the late shareholders in that company, which has now ceased to exist, depending upon the solution of the difficulties that have arisen with respect to their rights in Newfoundland.

It is announced that on the 1st July, the directors of the Anglo-American Telegraph Company pay the balance of the dividend of 2 per cent, free of income-tax, for the period ending the 30th of April.

The directors of the Brazilian Submarine Telegraph Company, Limited, have made a call of £2 per share, payable on the 1st.

A final call of £4 is payable on the new shares of the Eastern Telegraph Company, Limited, on the 2nd July.

On the 1st July, Messrs. C. J. Hambro and Son pay the interest then due, at 5 per cent per annum, on the shares of the Great Northern Telegraph Company.

The transfer books of the Eastern Extension, Australasia, and China Telegraph Company, Limited, were closed from the 24th to the 28th June, preparatory to paying an interim dividend of 3s. per share for the quarter ended 31st March.

The directors of Hooper's Telegraph Works, Limited, announce an interim dividend of 15s. per share, payable on the 20th July.

Mr. Cyrus W. Field and Mr. Charles W. Earle have joined the Board of the West India and Panama Company.

The Eastern Telegraph Company announce the opening of a duplicate cable from Cornwall to Spain, and a reduction of the rate from 12s. 6d. to 8s. Messages intended for transmission by the new route should be ordered *via* Falmouth and Vigo. Important telegrams for the South of Spain should continue to be sent *via* Lisbon. The rate by this route is from this day made a uniform one of 8s. for all Spanish correspondence by both of the Eastern Company's lines. The rate to Portugal is also reduced from 10s. 6d. to 8s. 6d.

TELEGRAPH SHARE LIST.

Amount per Share.	NAME OF COMPANY.	Amount paid up.	Closing Quotations.
£		£	June 27.
Stock	Anglo-American (Limited)	100	144—146xd
10	Brazilian Submarine..	5	2—1½ dis.
10	Cuba	All	9½—10
10	Eastern Telegraph Co.	All	9⅝—9⅞
10	Ditto Extension	All	9¼—9½xd
10	Great Northern	All	9¾—10¼xd
20	Great Western	13	— —
25	Indo-European	All	16—18
10	Mediterranean Extension (Limited)	All	5½—6
20	New York, Newfoundland, and London	20	21¾—22¼
8	Reuter's..	All	10½—11½
20	Société Transatlantique Francaise..	All	33¾—34¼
Stock	Submarine	100	230—240
Cert.	Ditto Cables Trust	100	114—119
10	West India and Panama	All	7½—8
10	Hooper's Telegraph Works	All	13¾—14¼
50	India-Rubber and Gutta Percha ..	All	35—37
12	Telegraph Construction	All	34½—35
Cert.	Ditto Ditto 3 years' Bonds	100	105—107
20	Direct United States Cable	81	— —
1000 dls.	West Un. U.S. 7 per cent 1st M.B.	All	91—93

The Brazilian Cable Expedition.—Pressure on our space compels us to postpone our report of the new cable ship named the *Hooper*, and of the cables to be laid between Pernambuco and Para, until our next issue. At a meeting on board the cable ship, on Friday, June 20, Sir William Thomson said:—"The cable is indeed a masterpiece of electrical and mechanical art. It has qualities superior to those of any cable that has ever before been sent away. Its insulation is higher—many times higher—and that in itself is a very great advantage. But I look upon the paramount quality of this cable for the purposes for which it has been made, as being its capability of resisting the dangerous influences of high temperature. I could not go to sea with anything like the same feeling of confidence, to cross the Equator, and to lay a cable under the burning suns of the coast of Brazil, that I could when I know the quality of the cable which we have on board. I speak this with the full consciousness of the great successes which have been obtained in laying cables under widely different circumstances, carrying them across the tropics, and laying them in seas where the temperature is certainly very high; but, even with that knowledge, I say advisedly that I feel greater confidence by far in going to sea with this Hooper cable than I possibly could in going to sea with a gutta-percha cable." Mr. Hooper was glad to see that his friend Mr. Jenkin had joined them. He should like to know whether Mr. Jenkin had ever seen any reason to alter his opinion, for, if he remembered rightly, that gentleman on one occasion said he feared the difficulties were so great that they would prevent the thing from becoming a successful commercial operation. Professor Jenkin said that he very often had the pleasure of being right, but on this occasion he had even greater pleasure in being wrong. Everyone, he believed, felt some doubt at the commencement of the undertaking, and it took some years to convince. He was most thoroughly satisfied, and unless he had felt perfectly certain that the core was a success, and that the cable could be successfully carried out, he should not have joined in such an undertaking. He could confirm every word that Sir William Thomson had said. Professor Jenkin then, in very complimentary terms, proposed "The health of Messrs. Mitchell and Co.," the builders of the ship, and referred to her whole construction in so short a space of time as a miracle of engineering. The vessel was signalled passing the Lizard signal station on Sunday, the 22nd, at 6.40 p.m.

A Chinese junk was recently seized at Hong Kong having on board some stolen telegraphic cable, supposed to be a portion of the Great Northern line.

Patents.

1641. G. Haseltine, LL.D., of London. *An improved apparatus for effecting and maintaining a separation between two dissimilar liquids or between a liquid and any substance held in solution or suspension therein; parts of which invention are applicable to the construction of galvanic batteries.* A communication from F. L. Pope, of New Jersey, and W. H. Sawyer, of New York, U.S.A. Dated May 7, 1873. This invention consists, first, in a process for separating two liquids or freeing a liquid from any substance held in solution or suspension therein. Second. In the combination of a galvanic battery, or other suitable generator of electricity, a vessel for containing liquid, and a continuous conductor capable of being traversed throughout by a current of electricity. Third. In a galvanic battery having its negative element formed of a circuitous conductor. Fourth. In the combination of a feeding tube or reservoir with a battery, whereby the negative salt may be supplied without interrupting the action of the battery.

3448. W. R. Sykes, of Nunhead, Surrey, and F. R. Francis, of New Kent Road. *Improvements in working railway signals, in registering the arrivals and departures of trains.* Dated November 19, 1872. According to this invention the signals are worked automatically, and the times of arrival and departure of trains are registered automatically. The train in passing a signalling point presses upon a spring (which is sufficiently strong to resist the weight of men passing over it), and causes this spring to make connection with electro-magnets for working the signal-lamps or arms. The signals are thus moved to danger; they are subsequently returned to caution or all right by the train in passing over another spring at a suitable distance from the first, acting in like manner upon other electro-magnets in connection with the same signals. The arrangement may be such that the train in passing over a spring returns the signals at a previous station to caution or all right, and at the same time, by other electro-magnets, sets the signals at the point it is passing to danger. Improved arrangements of signal-lamps enable the electro-magnets to actuate the signals without difficulty. The registration of the times of arrival and departure of trains is effected by the said springs, on being pressed down by the train being put in connection with a marker for marking a strip of paper which is caused to travel by clockwork. The strip has the hours and minutes embossed on it as it travels by rollers, also driven by the clockwork; hence the mark caused to be made by the passing train will appear on the paper immediately opposite the corresponding time as embossed on the paper.

3474. S. F. Van Choate, of London, Telegraphic Engineer. *Improvements in the mode of and apparatus for telegraphing.* Dated November 21, 1872. My invention relates to apparatus whereby signals, letters, or other characters, are produced by the actinism of a beam of light on sensitive or chemically-prepared paper, or other suitable moving surface, or by a suitable chemical agent or fluid acting on a moving surface chemically prepared or otherwise. The beam of light may proceed from a movable reflecting mirror, but I prefer that the said beam of light should be immovable. I provide clockwork to move the paper or other body or surface, on which I desire to produce or fix the letters or characters, and I arrange, in a peculiar manner, patterns, stencils, or formers, upon which the beam of light is caused by magnetism to play or move. In carrying into practice the part of my invention in which the beam of light is entirely dispensed with, I use a camel's-hair pencil, or other like instrument, which is attached to the moving armature of a magnet.

3492. C. E. Wetton, of Cheltenham, Journalist. *Improvements in portable appliances in magneto-therapeutics.* Dated November 22, 1872. Portable magnets are adapted for application to various parts of the human body without the necessity of covering or surrounding the metal of which they are composed with an elastic or flexible material, as usual; but oxidation is prevented as required, by electroplating the magnetic appliance, whether it be in the form of a metallic webbing or otherwise.

The Shah of Persia.—During the visit of the Shah to this country, direct telegraphic communication has been established between Buckingham Palace and Teheran. The arrangements, in which the Shah has personally taken great interest, were under the direction of Dr. C. W. Siemens, F.R.S. On Wednesday evening, Dr. and Mrs. Siemens had the honour of entertaining at their residence, Palace Houses, several of the Royal Persian Princes and Ministers, who met there the Directors of the Indo-European Telegraph Company, the first and at present the only public enterprise in Persia. Their Royal Highnesses the Prince Il Khaneh, Itizad es Sultaneh, Hissam es Sultaneh, Nosret ed Dowleh, the Ministers of Foreign Affairs, of Public Works, and of the Royal Household, and other eminent members of the Persian suite, were present, and the general company included Major-General G. Tremenheere, General Sir Frederick Goldsmid, Colonel Innes, Majors Smith and St. John, and Captain Lovett, from the Telegraph Department of the Persian Gulf, Mr. W. H. Barlow, F.R.S., Mr. H. Weaver, Mr. W. Andrews, and others. This is probably the first occasion on which our Persian visitors have been guests at other than an official public entertainment.

Review in Honour of the Shah of Persia.—An interesting feature in the review held by Her Majesty the Queen in Windsor Great Park was the telegraph cable, which was carried from the Windsor post-office over the houses in Park-street to the western fence of the Long Walk, over Brook-street, the Magpie Style, and the cross roads. The cable was hung upon trees. Upon reaching the "double gates" the wire was taken along the fence of Queen Anne's Meadow to the trees on the east side of Queen Anne's Ride to a telegraph-station erected near the stand provided by Prince Christian for the representatives of the press, and near the saluting post, where her Majesty's carriage stood. In addition to the facilities thus provided for the press, her Majesty the Queen received her private telegrams on the review ground. The Queen's telegrams are extremely numerous, and while her Majesty is at Windsor arrive in rapid succession from all parts of Europe and elsewhere, necessitating the employment of a special clerk for this particular service.

Telegraph Service of the United States.—For the 1st of January, 1873, the telegraphic system of the United States may be thus approximately estimated:—Aggregate nominal capital, 60,000,000 dols.; length of lines, 80,000 miles; length of wire, 180,000 miles; number of stations, 6300.

Mr. Highton has discovered, in the course of some experiments, that vegetable tar, by the addition of the oxides of lead (or in a less degree by some other substances), is almost instantly solidified, and that the solid substance thus obtained has remarkable insulating powers. In some experiments at Silvertown, it was found that No. 18 copper wire, covered with a coating of gutta-percha weighing only 21 lbs. to the mile, had its insulation increased nearly 200,000 per cent, and that the insulation resistance was no less than 2,800,000,000 units, an insulation sufficient for any lengths possible on the surface of the earth.

Work is to be commenced at once on the telegraph line between Arizona City and San Diego, California.